EEG-based Biometric Identification

Pilot study

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The history...

- earlier civilisations – thieves deprived of hand, tattooed (Roman empire)[1],
- mid 1800s – photography,
- 1870 – Bertillon system, body dimensions,
- 1903 – massive advent of fingerprinting (result of a slow evolution),
- 20th century methods: voice recognition, iris/retina scans, face recognition,
- near future: walking pattern used with mobile phone for owner recognition (anti-theft measure)[2].

[1] http://onin.com/fp/fphistory.html

[2] http://www.newscientist.com/article.ns?id=dn8161

EEG – a neglected alternative

- EEG is genetically conditioned – no doubts!
- A lot of evidences:
  1. medical/neurological research[1],
  2. brain-computer interface experiments[2],
  3. medical diagnostic methods.
- Brain-activity manifestation
  1. mental states recognition
  2. movement-related states recognition

[1] Y. Tran, A. Craig, P. McIsaac. Extroversion-introversion and 8-13Hz waves in frontal cortical regions. In *Personality and individual differences 2001*; 30:205-215.

[2] Jaromír Doležal, Jakub Šťastný, and Pavel Sovka. Recognition Of Direction Of Finger Movement From EEG Signal Using Markov Models. In *Proceedings of the 3rd European Medical & Biological Engineering Conference - EMBEC´05. Prague, Czech Republic*, volume 11 of *IFMBE Proceedings*, pages 1492–1 – 1492–6, 20-25.11.2005.

Our research target

Long-term targets

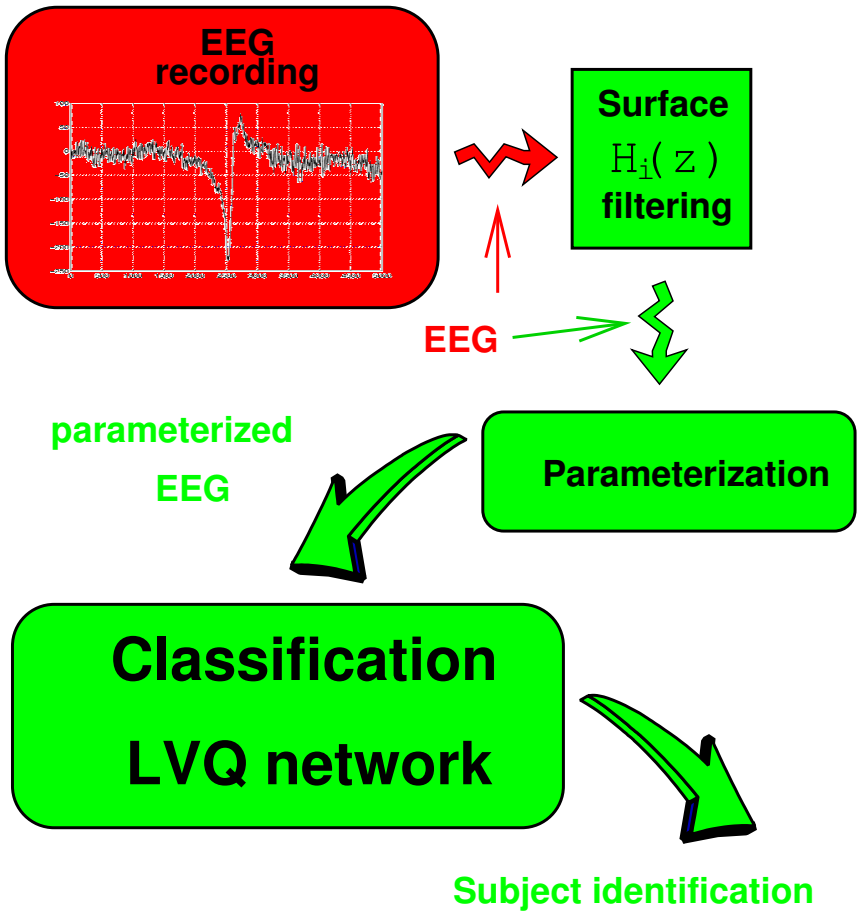
- a reliable authentication method
- a prototype authentication device

This step's target: There are only a few articles on this topic there. We wanted to:

- check the feasibility of the identification itself,
- check our database suitability,
- use resting sensorimotor EEG for this.

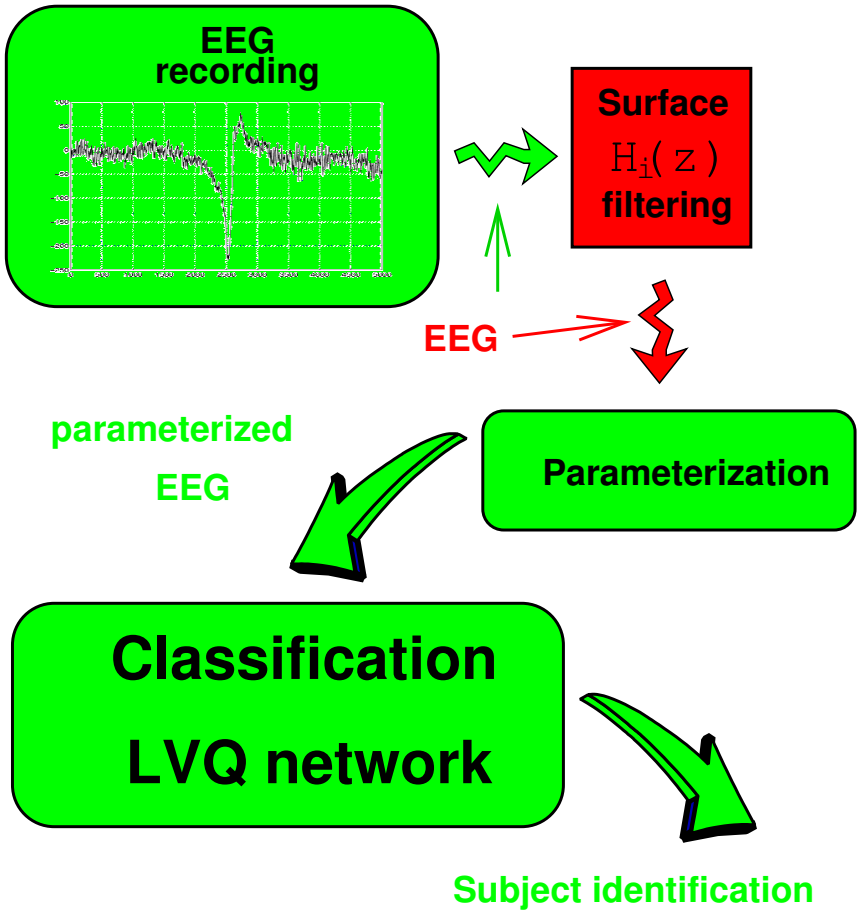
Single trial, off-line processing.

Our experiment – EEG recording



- 8 experimental subjects (7 men, 1 woman),
- 41 AgCl electrodes over sensorimotor cortices,
- resting subject, idling sensorimotor μ rhythm recorded,
- up to 20 min. of EEG per subject.

Modified Laplacian filtering



- smearing suppression, signal-to-noise ratio improvement
- eight neighbours method,
- our EEG samples sequentially – integrated sampling error compensation[a] [b]

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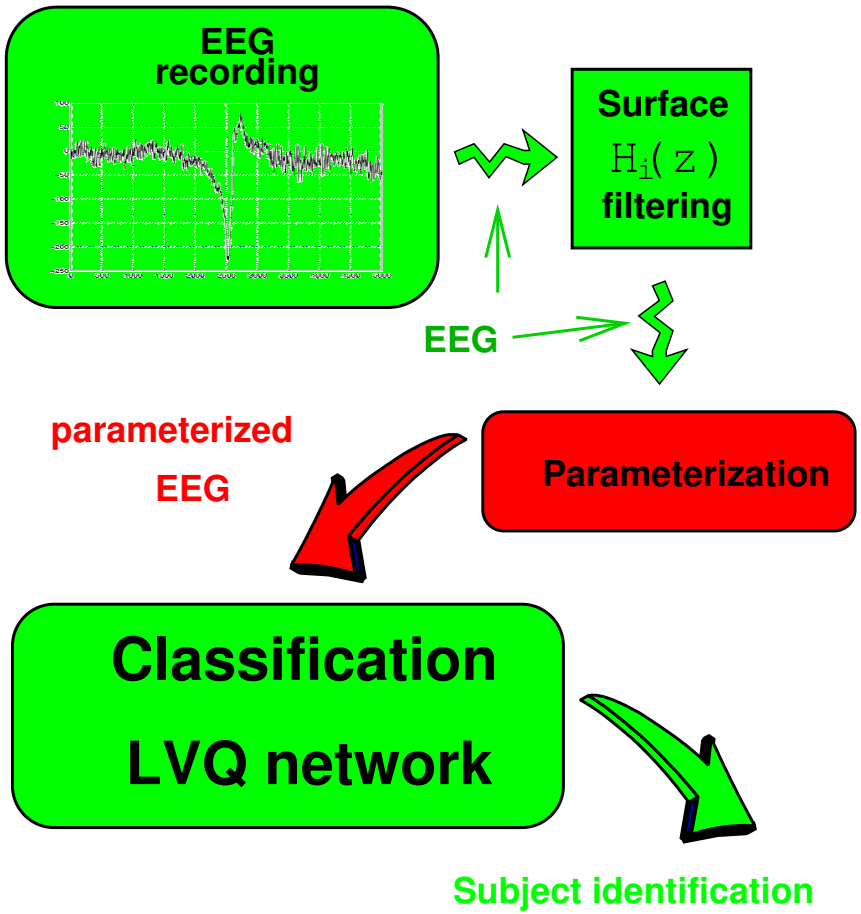
[a] Jakub Šťastný, Pavel Sovka The 3D Surface Laplacian Filtration With Integrated Sampling Error Compensation. Accepted for publication in Signal Processing, Elsevier. In press.

[b] Jakub Šťastný, et al. The Influence Of The EEG Recording Machine Time Multiplex On The Laplacian Filter: The Simulation With The Real Shaped Head Model. In Proceedings – EMBEC´05. pages 1506–1 – 1506–4

Parameterization



- Fourier transform[a] [b],
  - spectral resolution 1/180 Hz,
  - time resolution 22 sec,
- only μ band used for recognition (9-12Hz, 720 parameters),
- about 20 signal realizations per subject.

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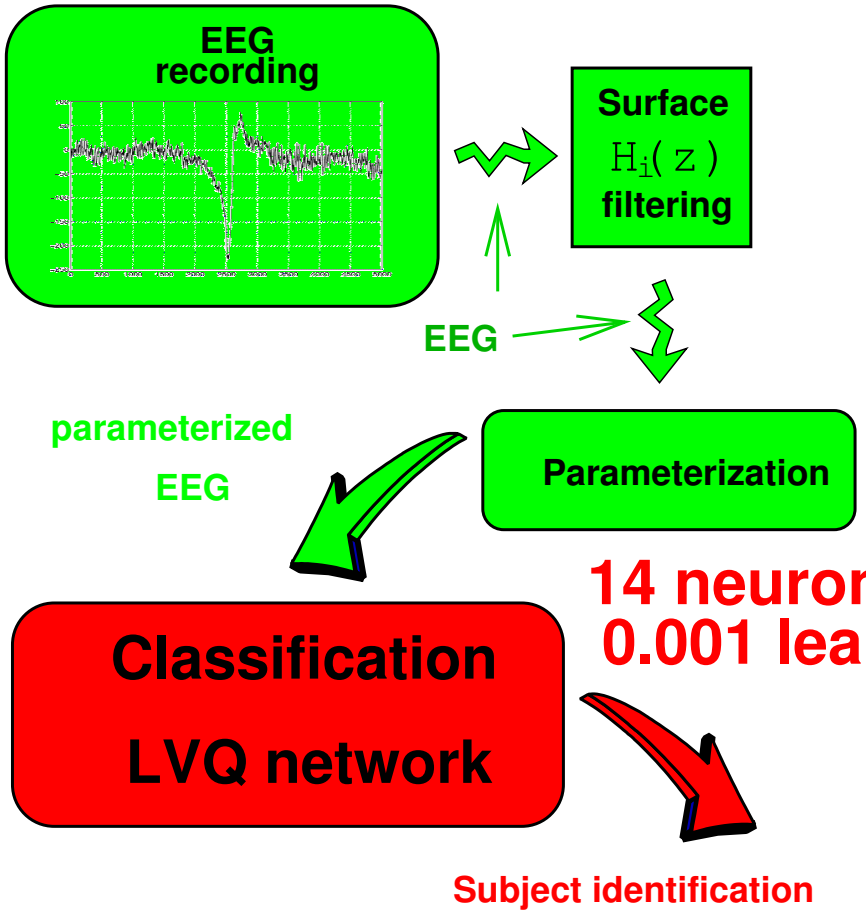
[a] M. Poulos,M. Rangoussi,N. Alexandris,A. Evangelou. On the use of EEG features towards person identification via neural network. In *Med Inform Internet Med.*, 2001;26(1):35-48.

[b] M. Poulos,M. Rangoussi,N. Alexandris,A. Evangelou. Person identification from the EEG using nonlinear signal classification. In *Methods Inf Med.*, 2002;41(1):64-75.

Classification



- small number of realizations → randomization procedure[a]:
  1. realizations randomly assigned into disjoint training and testing sets,
  2. classifier trained, testing performed,
  3. repeat steps no. 1 and 2 ten times,
  4. compute average classification scores.

[a] J. Šťastný , P. Sovka, and A. Stančák, EEG signal classification, in Abstract book, 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology, Istanbul, Turkey, p. 132, October 2001.

Classification scores

		Subject recognized as...							
		1	2	3	4	5	6	7	8
R	1	50%	13%	1 %	2 %	12 %	1 %	1%	20%
E	2	–	98%	–	–	2%	–	–	–
A	3	4%	13%	47%	30%	–	1%	1%	3%
L	4	–	–	–	100%	–	–	–	–
	5	–	2%	–	–	98%	–	–	–
S	6	1%	2%	1%	–	–	95%	1%	1%
B	7	12%	13%	21%	26%	1%	3%	10%	13%
J.	8	–	–	–	–	1%	2%	–	97%

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- 5 out of 8 subjects are identifiable on the 95% confidence level
- subjects 1,3, and 7 – poor classification score[1]

[1] Our thanks go here to Michal Cempirek who analysed the subject's spectra and computed the similarities.

Conclusions

Current results:

- state-of-the-art results verified and further extended,
- EEG-based subject identification is really possible.

Next steps:

- personal features analysis,
- parameterization optimization,
- implementation of the prototype subject identification system,
- two-factor authentication[1].

Open question:the unambigousness of the identification?

[1] J. Thorpe, P.C. Van OOrschot, A. Somayaji. Pass thoughts: Authenticating With Our Minds. In *Cryptology ePrint Archive*, Report 2005;121 (eprint.iacr.org)

Thank you for your attention

News on our research, other publications, this article and presentation (will be posted on the WWW on Tuesday) are downloadable from

`http://amber.feld.cvut.cz/fpga`

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